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A comparative analysis of 21st -century teaching competency perceptions among preservice teachers: Mahasarakham university

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Abstract

This study investigated the 21st-century teaching competencies of preservice teachers at Mahasarakham University, with particular attention to perceived competency levels, gender-based differences, and disciplinary variations. A mixed-methods research design was employed, involving 190 final-year preservice teachers enrolled in professional experience training. Quantitative data were collected through a validated questionnaire encompassing five core domains: learning design and instructional management, innovation and information technology, authentic assessment, research for learning development, and moral, ethics, and teachers' professional ethics. We collected qualitative data by interviewing 10 preservice teachers. Descriptive statistics and inferential analyses were conducted, supplemented by qualitative data from open-ended responses and interviews. The findings revealed that the overall competency level was high ($\bar{x}$ = 4.32, S.D. = 0.35), with the highest scores in professional ethics and the lowest in research-related competencies. Male preservice teachers reported significantly higher scores in instructional design, while students majoring in humanities rated themselves higher in assessment and research domains compared to their peers in science-related fields. Qualitative feedback emphasized challenges in using advanced educational technologies and conducting research independently, citing limited digital infrastructure and insufficient support in research writing. The results underscore the need for curriculum enhancement, targeted support based on gender and disciplinary needs, and improved digital resources to foster more balanced professional growth.

Keywords: 21st-century competencies, Mahasarakham University, Preservice teachers.

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1. Introduction

The accelerating transformation of the 21st century, driven by digital technologies, global interconnectedness, and shifting workforce expectations, has significantly redefined the professional profile of teachers [1-3]. Educators are no longer viewed solely as conveyors of subject knowledge; instead, they are expected to facilitate learning environments that promote innovation, critical thinking, collaboration, and adaptability [4, 5]. As global education systems respond to these shifts, the readiness of future teachers to navigate this context has become a pressing concern. One critical issue that emerges is whether preservice teachers, particularly those in the final phase of their training, can demonstrate the competencies demanded by contemporary classrooms.

The 13th National Economic and Social Development Plan of Thailand (2023–2027) [6] lays out plans for improving students' digital skills, developing teachers with strong academic skills, learning leadership skills, technological proficiency, and the ability to use new technologies through a variety of online platforms. It also stresses the need to make student evaluation systems more varied and authentic, as well as the necessity to use formative assessments to change and improve learning management so that it meets the needs of each student and is linked to future jobs. It also aims to equip college students with the critical skills they need for future employment and innovation, help them conduct better research, and teach them strong values, ethics, and how to be responsible citizens.

The Basic Education Development Plan of Thailand (2023–2027) [7] also lists the most important 21st-century skills that kids and teens should learn. These are the 3Rs and 8Cs, which are skills for learning and coming up with new ideas. Reading, writing, and math are the 3Rs. The 8Cs are critical thinking and problem solving; creativity and innovation; cross-cultural understanding; collaboration, teamwork, and leadership; communication; information and media literacy; computing and ICT literacy; career and learning skills; and compassion.

In the Thai context, educational reforms have underscored the importance of developing teacher competencies that reflect the demands of modern learners [8]. National policy bodies and teacher education institutions have called for the integration of skills such as technological literacy, learner-centered pedagogy, and ethical professionalism into preservice training [9]. While teacher preparation programs across the country have made efforts to correspond with these expectations, questions remain regarding the extent to which these competencies are actually being acquired in practice. Teacher trainees, who represent the immediate future of the profession, must carry the weight of theoretical understanding and practical application of these competencies during their professional experience placements.

This study begins from the position that while many teacher education programs articulate 21st-century competencies in their curricula, the actual development of such competencies may vary across disciplines. Students in science-related fields often experience training environments that emphasize experimentation, data interpretation, and technology use, whereas those in the humanities may encounter more reflective, interpretive approaches. These distinctions can influence how preservice teachers perceive and internalize professional competencies. Moreover, encouraging students to engage in self-reflection through structured self-assessment during the practicum period provides insight into both their personal development and the strengths and limitations of their academic preparation.

The objective of this study is to investigate the perceived level of 21st-century teaching competencies among fourth-year teacher trainees at Mahasarakham University. Specifically, it aims to compare self-assessed competencies across academic fields and gender groups. Consequently, the study seeks to generate evidence that may inform the design of targeted support measures in teacher education programs, particularly in the final stages of professional training. The findings are intended to contribute to institutional quality assurance, curriculum enhancement, and the broader effort to prepare competent, forward-thinking educators.

2. Literature Review

Over the past two decades, international education bodies and researchers have increasingly emphasized the importance of equipping teachers with a broad range of competencies required for effective teaching in the 21st century. Frameworks such as the Partnership for 21st Century Learning (P21) [10] and UNESCO’s transversal skills model [11] have outlined key domains including critical thinking, collaboration, communication, creativity, digital literacy, and global citizenship [12]. These competencies are no longer viewed as supplementary but are positioned as essential attributes of teachers who must navigate complex learning environments and support student success in an interconnected world. As a response, teacher education programs globally have been called upon to restructure curriculum and pedagogy to ensure that these competencies are systematically developed during preservice training. The foundational education levels in Thailand emphasize the development and specification of the national education plan, enabling educators to incorporate technology, ethics, authentic assessment, and active learning methodologies [6, 7].

In this regard, the present study adopts a model that reflects five major domains commonly found in existing frameworks: instructional design and management, use of information and communication technologies (ICT), authentic assessment, classroom-based research, and ethical-professional conduct. These areas reflect both foundational and emergent expectations of teachers who must operate in rapidly evolving educational contexts, particularly within systems undergoing reform. The focus on self-perceived competencies during the practicum phase aligns with a broader move toward reflective and evidence-informed teacher preparation.

The development of 21st-century competencies has been explored from various angles. For example, Namsone et al. [13] proposed a theoretical model for teacher self-assessment using performance descriptors across a range of competency domains, supporting data-driven professional development. Similarly, Nebot et al. [14] examined digital teaching competence among Spanish university lecturers, offering diagnostic insight into strengths and areas needing support. Poonputta and Nuangchalerm [15] studied a needed competency in the 21st century for elementary school teachers in the

northeastern region. The results of the research were that teachers need competencies in research and development first, followed by competencies in media and information technology, competencies in designing and managing active learning, competencies in measuring and evaluating real-world learning outcomes, competencies in building learning communities, and competencies in morality, ethics, and professional ethics [16]. Study a need to enhance pre-service teachers' digital competencies, the results showed that: the components of pre-service teachers' digital competencies have 6 components; (1) using search engines (2) creativity and innovation (3) identity and quality of life (4) teaching and learning technology (5) tools and technology and (6) communication and collaboration. The survey results showed that instructors have the highest level of need to enhance pre-service teachers' digital competencies.

Beyond structural models, several studies have examined reflective practices as a mechanism for competency development. Erdemir and Yeşilçınar [17] demonstrated that self-reflection and teacher feedback were perceived as more beneficial than peer feedback in helping preservice teachers refine their teaching strategies. Ivanova-Armeykova Rositsa [18] emphasized the role of educational reflection in building empathy, ethical awareness, and professional judgment. Pang [19] further illustrated how teachers' reflective statements, especially regarding assessment strategies, could lead to meaningful pedagogical adjustments.

In terms of soft skills and contextual variation, Antón-Sancho et al. [20] focused on university teachers in Latin American countries with low digital infrastructure. Their findings suggest that, despite technological limitations, strong soft skills can support digital adaptation. This is particularly relevant to developing countries, where infrastructural constraints often challenge teacher readiness in digital pedagogy. Similarly, Walan and Brink [21] explored both student and teacher responses to digital self-assessment tools and found that while such tools promote awareness of 21st-century competencies, they also demand sustained teacher support and contextual adaptation.

Despite the breadth of research on teacher competencies, comparative studies focusing specifically on preservice teachers remain limited. Most existing research has been conducted at the in-service or university faculty level, leaving a gap in understanding how competencies are perceived and developed during the formative stage of teacher preparation. Among the reviewed studies, only Niu et al. [22] explicitly investigated student teachers' perceptions of their 21st-century competencies, using a mixed-method design in the Finnish context. Their study identified collaboration as the most well-developed area and global awareness as the least, while also highlighting the value of interactive, well-supported coursework. However, their context, characterized by strong institutional systems and high digital access, differs significantly from the conditions faced by preservice teachers in less digitally equipped environments. This signals the need for further research in diverse educational contexts, particularly in countries such as Thailand, where teacher education programs are undergoing rapid adaptation amid shifting policy demands. The purposes of the study were to examine the level of 21st-century teaching competencies among preservice teachers at Mahasarakham University during their professional experience training and to compare the perceived competency levels across academic disciplines and gender to identify possible differences in preservice teachers' readiness for contemporary teaching demands.

3. Methodology

3.1. Research Design

This study employed a convergent parallel design mixed method approach [23, 24]. The quantitative research was conducted by preservice teachers through questionnaires, and the approach was cross-sectional in nature, capturing self-reported data from participants during the final semester of their professional experience practicum. The study sought to provide a comparative snapshot of how teacher trainees assess their readiness in key domains aligned with 21st-century education. The qualitative data collection was carried out through interviews with the preservice teachers.

3.2. Samples

The target population consisted of 362 fourth-year preservice teachers enrolled at Mahasarakham University, Thailand, who were undertaking their professional practicum during the second semester of the 2024 academic year. Using stratified random sampling based on academic discipline, a sample of 190 students was selected: 90 from science-related programs (e.g., general science, mathematics, educational technology) and 100 from humanities-related programs (e.g., Thai language, English, social studies, early childhood education) (Table 1). 10 research participants for qualitative research.

Table 1.
Population (N) and Samples (n).

Academic Discipline	N	n
Science Group	172	90
Humanities and Social Sciences Group	190	100
Total	362	190

The participants represented a diverse range of instructional specializations, yet all shared a common foundation in teacher training. As final-year students, they had already completed coursework in instructional planning, classroom management, and assessment, and were actively applying these competencies in real classroom settings under supervision. Their direct engagement in schools during the practicum provided an authentic basis for self-evaluation. Prior to data collection, participants were informed about the research objectives, assured of anonymity, and invited to provide informed consent, in compliance with ethical guidelines for research involving human subjects.

3.3. Research Instruments

3.3.1. Questionnaire

The primary instrument used in this study was a structured questionnaire consisting of 59 items divided across five key competency domains: (1) learning design and instructional management, (2) innovation and information technology use, (3) authentic assessment, (4) research for learning development, and (5) moral, ethics, and teachers' professional ethics. Each item employed a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The questionnaire was developed based on theoretical frameworks from both international and local research and was subsequently validated by five experts in the fields of educational measurement, teacher education, and instructional technology. The questionnaire was evaluated to have content validity (IOC = 0.60–1.00).

To ensure content clarity and reliability across all five domains, discrimination indices (r_{xy}) and Cronbach's alpha coefficients (α) were examined separately for both current competency levels and perceived developmental needs. The current competency resulted in appropriate item discrimination (r = 0.32–0.80) and reliability (α = 0.97), and the developmental needs resulted in appropriate item discrimination (r = 0.52–0.98) and reliability (α = 0.99) (Table 2).

Table 2.
Instrument evaluation.

Competency Domain	Current competency		Developmental Need	
	Discrimination (r_{xy})	**Reliability (α)**	**Discrimination (r_{xy})**	**Reliability (α)**
Learning design and instructional management	0.32–0.78	0.97	0.52–0.93	0.99
Innovation and Information Technology	0.40–0.78		0.67–0.97	
Authentic Assessment	0.36–0.69		0.75–0.98	
Research for Learning Development	0.38–0.78		0.61–0.95	
Moral, Ethics and Teachers' Professional Ethics	0.38–0.80		0.76–0.96	

3.3.2. Interview

To complement the quantitative data, a semi-structured interview form was developed to explore participants' perceptions of their 21st-century teaching competencies in greater depth. The interview protocol included open-ended questions aligned with the five core competency domains. Three experts in education reviewed the items for content validity, and minor revisions were made to enhance clarity. The interviews were conducted with selected preservice teachers representing different majors and genders to ensure diverse perspectives. Responses were audio-recorded, transcribed, and thematically analyzed.

3.4. Data Collection and Data Analysis

Data were collected in February 2025 during the end-of-semester seminar in which all practicum students participated. The researcher distributed the questionnaires in person, provided a brief explanation of the study's purpose, and ensured that participants had the opportunity to ask questions before completing the forms. Participants were informed that their responses would have no bearing on academic standing and were encouraged to respond honestly. Questionnaires were returned anonymously either directly to the researcher or via a sealed collection box placed at the seminar venue. Quantitative data were analyzed using descriptive and inferential statistics. t-tests and one-way ANOVA were employed to examine the differences between variables. In addition, the Priority Needs Index (PNI) was calculated to identify areas in which students reported a gap between current competency and perceived developmental need.

4. Results

4.1. Background Information and Teaching Methods, Materials, and Technology (Tables 3-6)

The study involved a total of 190 preservice teachers. Of these, 134 were female (70.53%) and 56 were male (29.47%). Participants were enrolled in two major academic discipline groups: the science group, which included fields such as general science, mathematics, technology, and educational media (47.37%), and the humanities and social sciences group, comprising programs such as social studies, English, Thai, and early childhood education (52.63%). Regarding practicum placement, over half of the participants (56.32%) conducted their professional experience in Mahasarakham province, followed by 17.89% in Chaiyaphum, 15.79% in other provinces, and 10% in Kalasin. This distribution reflects the university's partnerships with regional schools and its commitment to localized teacher training. (Table 3).

Table 3.
Informants' background information.

Variable	Category	n	%
Gender	Male	56	29.47
	Female	134	70.53
	Total	190	100.00
Academic Discipline	Science Group	90	47.37
	Humanities and Social Sciences Group	100	52.63
	Total	190	100.00
Practicum Province	Kalasin	19	10.00
	Chaiyaphum	34	17.89
	Mahasarakham	107	56.32
	Khon Kaen	30	15.79
	Total	190	100.00

During their teaching practicum, preservice teachers employed a diverse range of instructional methods. The most frequently reported approach was game-based learning and gamification (32.63%), highlighting a preference for interactive and student-centered techniques. Lecture-based instruction remained common (25.79%), followed closely by cooperative learning strategies (25.26%) and inquiry-based models such as the 5E and 7E frameworks (24.74%). Other notable methods included mind mapping (15.79%), brain-based learning (14.21%), and competency-based instruction (14.21%). Less commonly used approaches, such as model-based learning (4.74%), KWL/KWDL strategies (3.68%), and TPACK-based teaching (2.11%), were also reported. A variety of additional models (e.g., role play, POE, CLIL) were noted under the "Others" category (12.63%), reflecting the eclectic and adaptive nature of teaching practices among the cohort. (Table 4).

Table 4.
Teaching Methods Reported by Preservice Teachers during Practicum (N = 190).

ID	Teaching Method	n	%
1	Game-Based Learning, Gamification	62	32.63
2	Lecture Method	49	25.79
3	Cooperative Learning (e.g., STAD, TGT, Think–Pair–Share, Jigsaw, GI)	48	25.26
4	Inquiry-Based Learning (e.g., 5E, 7E Models)	47	24.74
5	Mind Mapping	30	15.79
6	Brain-Based Learning (BBL)	27	14.21
7	Competency-Based Learning	27	14.21
8	Purpose-Driven Instruction	19	10.00
9	STEM Education	13	6.84
10	Problem-Based Learning (PBL)	13	6.84
11	Strategic Reading Models (e.g., SQ4R, SQ6R, CIRC)	13	6.84
12	Direct and Indirect Instruction	12	6.32
13	Project-Based Learning (PjBL)	9	4.74
14	Model-Based Learning (MBL)	9	4.74
15	KWL/KWDL	7	3.68
16	SCAMPER and SCSS	5	2.63
17	TPACK-Based Instruction	4	2.11
18	GPAS 5-Step Model	4	2.11
19	Creative-Based Learning (CBL)	3	1.58
20	Question-Based Approaches (e.g., 2W3P, 5W1H)	3	1.58
21	Others (e.g., POE, VARK, CGI, Role Play, 4MAT, CLIL, etc.)	24	12.63

In terms of instructional media and teaching materials, the vast majority of preservice teachers relied heavily on worksheets or exercise sheets (72.11%), followed by activity sets (42.11%). Flashcards and alphabet cards were also frequently used (21.58%), supporting foundational literacy and vocabulary development. Less frequently employed resources included slide presentations (7.89%) and small storybooks (7.37%), indicating occasional integration of digital and narrative tools. Innovative or game-based materials such as the "Magic Box" (2.63%), reading boards (2.11%), and board games (2.11%) were used sparingly. Very few participants reported using tools like word cards, bingo games, or experimental equipment, which were grouped under "Others" (4.74%) (Table 5).

Table 5.
Teaching Materials and Instructional Media Used by Preservice Teachers during Practicum (N = 190).

ID	Teaching Material / Media	n	%
1	Worksheets / Exercise Sheets	137	72.11
2	Activity Sets	80	42.11
3	Flashcards / Alphabet Cards	41	21.58
4	Slide Presentations	15	7.89
5	Small Storybooks	14	7.37
6	Magic Box	5	2.63
7	Reading Boards	4	2.11
8	Board Games	4	2.11
9	Word Cards / Word Banks	2	1.05
10	Bingo	2	1.05
11	Others (e.g., lab equipment, visual aids, etc.)	9	4.74

The analysis of technology integration during the practicum revealed that preservice teachers heavily favored presentation tools, with PowerPoint and Canva being the most frequently utilized (82.63%). Video platforms such as YouTube (53.16%) and interactive quiz tools like Kahoot (52.63%) and QUIZZIZ (47.37%) were also widely adopted, highlighting a preference for visual and gamified learning support. Less commonly employed were children's e-books (11.58%) and interactive worksheet tools like Liveworksheets (10.00%). Only a small percentage made use of platforms like Plickers, e-learning systems, or programming tools such as Blockly Game, each under 6%. Emerging tools like Padlet, Wordwall, Vonder, and others (e.g., Roblox, worksheets, Google Forms) were used by fewer than 3% of participants. (Table 6).

Table 6.
Digital Tools and Educational Technologies Used by Preservice Teachers during Practicum (N = 190).

	Educational Technology Used	n	%
1	PowerPoint / Canva	157	82.63
2	YouTube	101	53.16
3	Kahoot	100	52.63
4	QUIZZIZ	90	47.37
5	E-books (Children's Digital Books)	22	11.58
6	Live worksheets	19	10.00
7	Plickers	11	5.79
8	E-learning Platforms	9	4.74
9	Blockly Game	9	4.74
10	Blooket	7	3.68
11	Padlet	2	1.05
12	Vonder Game	2	1.05
13	Wordwall	2	1.05
14	Others (Roblox, Worksheet, Google Form)	4	2.11

4.2 Preservice Teachers' Perceived 21st-Century Teaching Competencies

The overall self-assessed 21st-century competencies of preservice teachers at Mahasarakham University were reported at a high level ($\bar{x}$ = 4.32, S.D. = 0.35). Among the five competency domains, the highest-rated was "Moral, Ethics, and Teachers' Professional Ethics" ($\bar{x}$ = 4.64), indicating strong ethical awareness and commitment to professional standards. This was followed by "Innovation and Information Technology" ($\bar{x}$ = 4.49), reflecting confidence in leveraging digital tools for teaching. Competencies in "Authentic Assessment" ($\bar{x}$ = 4.23), "Research for Learning Development" ($\bar{x}$ = 4.20), and "Instructional Design and Management" ($\bar{x}$ = 4.14) were also perceived at high levels (Table 7).

Table 7.
Preservice Teachers' Perceived 21st-Century Teaching Competencies (N = 190).

Competency Domain	$\bar{x}$	S.D.	Level
1. Learning design and instructional management	4.14	0.44	High
2. Innovation and information technology	4.49	0.40	High
3. Authentic assessment	4.23	0.46	High
4. Research for Learning Development	4.20	0.53	High
5. Moral, Ethics and Teachers' Professional Ethics	4.64	0.38	Very High
Overall	4.32	0.35	High

The qualitative data obtained from follow-up interviews enriched the interpretation of the survey findings by revealing specific challenges and contextual limitations faced by preservice teachers during their practicum. In the domain of instructional design and management, while participants expressed confidence, some struggled with implementing advanced frameworks like TPACK or designing community-integrated learning. One preservice teacher noted,

> *"We were told to connect the lesson to the local context, but no one guided us on how to actually do that at the school"* (Participant 6).

In terms of technology integration, despite high ratings in basic ICT use, obstacles such as limited digital infrastructure are frequently mentioned.

> *"The storage space in Google Drive is too small when students submit video assignments, it fills up quickly"* (Participant 4).

Regarding authentic assessment, many relied on conventional worksheets or tests, as practical assessment tools or lab equipment were often unavailable.

> *"Our school has a science lab, but there aren't enough materials, so I could only give exercises, not actual experiments"* (Participant 1).

In the research domain, preservice teachers reported difficulty with statistical analysis and academic writing.

> *"I forgot how to use SPSS and had to ask my friend to help analyze the data"* (Participant 2), and
> *"Writing the background and definitions in Chapter 1 was so hard, I kept revising them"* (Participant 3).

Finally, although professional ethics scored highest, some felt moral instruction was not emphasized enough.

> *"I do talk about ethics, but usually only when there's time left at the end of the lesson"* (Participant 7).

These insights suggest that while perceived competencies are high, the application of such skills is often shaped and sometimes constrained by external realities, indicating areas for curriculum and field supervision improvement.

The comparative analysis of preservice teachers' 21st-century competencies by gender is shown in Table 8. While the overall competency scores were similarly high for both male ($\bar{x}$ = 4.36, S.D. = 0.36) and female ($\bar{x}$ = 4.30, S.D. = 0.34) preservice teachers, a statistically significant difference emerged in the domain of *Learning design and instructional management*. Male students reported higher self-assessed competency ($\bar{x}$ = 4.29) than their female counterparts ($\bar{x}$ = 4.08), t = 2.99, $p < .05$. No significant differences were observed in the other domains, including technological integration, assessment, research, and ethics (Table 8).

Table 8.
Comparison of Preservice Teachers' 21st-Century Teaching Competencies by Gender (N = 190).

Competency Domain	**Male (n = 56)**		**Female (n = 134)**		***t***	***p***
	$\bar{x}$	**S.D.**	**$\bar{x}$**	**S.D.**		
1. Learning design and instructional management	4.29	0.40	4.08	0.44	2.99	0.00*
2. Innovation and Information Technology	4.49	0.39	4.49	0.41	0.09	0.93
3. Authentic Assessment	4.31	0.43	4.20	0.47	1.51	0.13
4. Research for Learning Development	4.14	0.55	4.01	0.52	1.55	0.12
5. Moral, Ethics and Teachers' Professional Ethics	4.54	0.46	4.68	0.33	-2.01	0.05
Overall	4.36	0.36	4.30	0.34	1.05	0.30

Note: *p-value < 0.05.

This study presents a comparison of 21st-century teaching competencies between preservice teachers in the science group and those in the humanities group. Overall, the humanities group demonstrated significantly higher competency levels ($\bar{x}$ = 4.37, S.D. = 0.35) compared to the science group ($\bar{x}$ = 4.26, S.D. = 0.33), t = -2.07, $p < .05$. Significant differences were found in two domains: *Authentic assessment, Innovation, and Information Technology* and *Research for Learning Development*. In both areas, humanities preservice teachers rated themselves significantly higher ($\bar{x}$ = 4.30 and 4.13, respectively) than their science counterparts ($\bar{x}$ = 4.15 and 3.97), with p values of .02 and .04, respectively. (Table 9).

Table 9.
Comparison of Preservice Teachers' 21st-Century Teaching Competencies by Academic Discipline (N = 190).

Competency Domain	Science Group (n = 90)		Humanities and Social Sciences Group (n = 100)		*t*	*p*
	$\bar{x}$	S.D.	$\bar{x}$	S.D.		
1. Learning design and instructional management	4.11	0.41	4.17	0.47	-0.87	0.39
2. Innovation and Information Technology	4.44	0.38	4.53	0.42	-1.42	0.16
3. Authentic Assessment	4.15	0.45	4.30	0.46	-2.27	0.02*
4. Research for Learning Development	3.97	0.52	4.13	0.53	-2.09	0.04*
5. Moral, Ethics and Teachers' Professional Ethics	4.60	0.38	4.68	0.38	-1.45	0.15
Overall	4.26	0.33	4.37	0.35	-2.07	0.04*

Note: *p-value < 0.05.

This study presents a comparison between the current competency levels and the perceived need for further development among preservice teachers across five 21st-century teaching competency domains. The Priority Needs Index (PNI) was calculated to determine which areas require the most immediate attention. The domain with the highest development need was *Research for Learning Development* (PNI = 0.15), indicating that preservice teachers see a clear gap between their current research skills and what is required in actual practice. This was followed by *Authentic Assessment, Innovation, and Information Technology* (PNI = 0.08), and *Instructional Design and Management* (PNI = 0.10), both considered areas needing urgent enhancement. Interestingly, *Moral, Ethics, and Teachers' Professional Ethics* showed a negative PNI (-0.02), suggesting that current competency levels slightly exceed the perceived requirement. Likewise, *Innovation and Information Technology* presented a near-neutral gap (PNI = -0.01), indicating perceived sufficiency in this domain. (Table 10).

4.3. Current 21st-Century Competency Levels and Development Needs of Preservice Teachers

Table 10.
Current 21st-Century Competency Levels and Development Needs of Preservice Teachers (N = 190).

Competency Domain	Current Competency Level			Development Need Level			PNI	Priority Rank
	$\bar{x}$	S.D.	Level	$\bar{x}$	S.D.	Level		
1. Learning design and instructional management	4.14	0.44	High	4.54	0.70	Very High	0.10	3
2. Innovation and Information Technology	4.49	0.40	High	4.45	0.88	High	-0.01	4
3. Authentic Assessment	4.23	0.46	High	4.58	0.71	Very High	0.08	2
4. Research for Learning Development	4.05	0.53	High	4.64	0.67	Very High	0.15	1
5. Moral, Ethics and Teachers' Professional Ethics	4.64	0.38	Very High	4.54	0.89	Very High	-0.02	5
Overall	4.32	0.35	High	4.55	0.72	Very High		

5. Discussion

The findings of this study contribute to the growing body of literature on teacher education by highlighting preservice teachers' self-assessed 21st-century competencies and the specific areas requiring targeted development. The overall high level of perceived competence suggests that the teacher preparation program at Mahasarakham University has been successful in cultivating foundational teaching skills, particularly in ethical responsibility and the integration of technology. These strengths align with prior research emphasizing the growing importance of digital competence and ethical responsibility in 21st-century teaching frameworks [25, 26]. Moreover, the findings correspond with the UNESCO transversal skills model, which identifies critical domains such as problem-solving, creativity, and responsible citizenship as essential for future educators [11].

Specifically, the five competency domains identified in this study, learning design, technology use, authentic assessment, research, and professional ethics, were perceived as important by preservice teachers, which aligns with frameworks and studies discussed in the literature review. [6, 7, 12, 27] emphasized that teaching in the 21st century requires the integration of digital tools, authentic learning assessment, and continuous professional growth through inquiry. Similarly, Ivanova-Armeykova Rositsa [18] underscored the importance of designing instruction that reflects real-world relevance and community connections, which was a noted area for improvement in this study.

However, qualitative data revealed important nuances. Despite high mean scores across all domains, preservice teachers expressed difficulty in designing instruction based on community contexts and in independently applying research skills. These findings suggest that self-assessed scores may not fully capture the complexity of teacher readiness. This supports earlier warnings by Tondeur et al. [28] who observed that preservice teachers often overrate their competence in digital and research domains due to limited hands-on opportunities. The concern was also reflected in interview responses, indicating a lack of practical access to school technology and insufficient confidence in conducting data analysis, suggesting the need for more applied learning opportunities.

Gender differences also emerged in instructional design, with male preservice teachers reporting higher self-efficacy than their female peers. This may reflect gendered self-perception patterns, as previously noted by Pajares [29] who found that confidence, rather than competence, often drives gender differences in educational self-assessment. On the other hand, female preservice teachers scored higher in professional ethics, aligning with the notion that relational and collaborative dimensions of teaching may be more strongly internalized by women.

In terms of academic background, students from humanities majors consistently rated themselves higher in assessment and research competencies compared to their peers in science. This mirrors findings by Zeichner [30] who argued that science-oriented programs tend to emphasize technical knowledge over pedagogical inquiry, whereas humanities-based programs often integrate reflective practices and classroom-based research more systematically.

Finally, the PNI-modified gap analysis identified specific areas for improvement, particularly in Research for Learning Development and instructional design using frameworks such as TPACK. Without sufficient competence in these areas, preservice teachers may struggle to adapt instruction to meet diverse student needs and analyze learning data effectively skills that are crucial for responsive and data-driven teaching in 21st-century classrooms [12, 27]. This aligns with the needs of full-time teachers who seek development with new technologies and teaching materials, such as the application of AI in teaching and the use of various educational applications.

Based on these findings, it is recommended that teacher education programs offer structured, mentored experiences in lesson planning, research implementation, and the integration of community-based learning. In addition, gender- and major-sensitive interventions may be necessary to ensure equitable competency development and support for all preservice teachers.

6. Conclusion

This study explored the self-assessed 21st-century teaching competencies of preservice teachers at Mahasarakham University, along with comparisons across gender and academic majors. The overall findings indicate that preservice teachers perceived themselves to possess a high level of competency, particularly in moral, ethics, and teachers' professional ethics. High ratings in this domain suggest that teacher preparation programs are effectively instilling a strong sense of professionalism and ethical awareness in future educators.

Despite these strengths, the study identified areas requiring further development. The lowest-rated domains were Research for Learning Development and authentic assessment, highlighting a need to reinforce research literacy and practical assessment strategies. Gender-based comparisons revealed that male preservice teachers rated themselves significantly higher in instructional design and management, suggesting the potential for differentiated support. Additionally, differences across academic majors indicate that humanities majors felt more confident in assessment and research competencies than those in science disciplines, possibly due to variations in pedagogical training emphasis.

The findings underscore the importance of strengthening university-school partnerships and allocating more resources for practice-based teacher education. Institutions should consider integrating competency-based frameworks into field experiences, ensuring alignment between coursework and classroom realities. Moreover, the digital infrastructure supporting online classrooms, such as cloud storage for assignments, should be expanded to meet preservice teachers' evolving instructional needs.

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